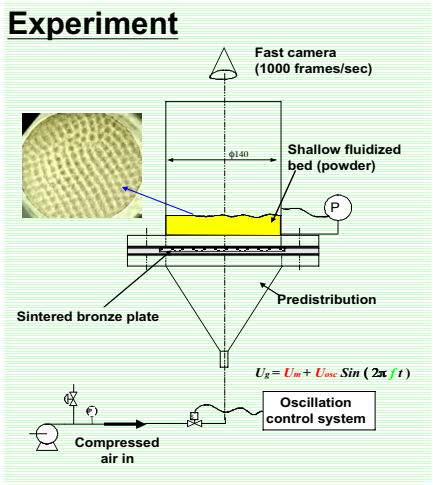
Periodic and Disordered Structures in Modulated Gas-Driven Granular Layers

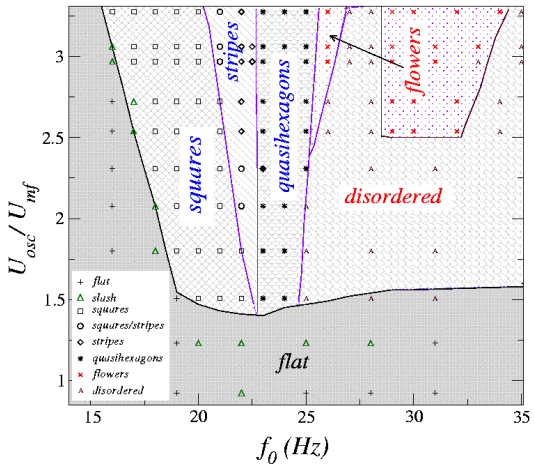
Jie Li, Igor Aronson, Wai-Kwong Kwok (ANL) and Lev Tsimring (UCSD)

Motivation

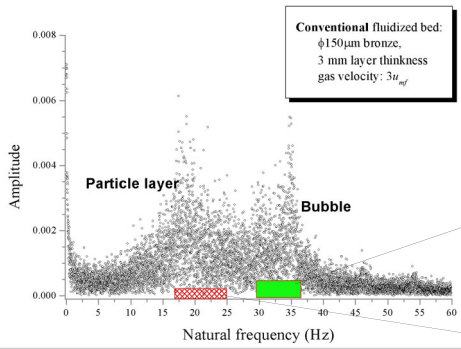
Gas-solid flow is a ubiquitous phenomenon, but prone to flow instability, e. g. bubbling & channeling. Pressure spectrum analysis provides a powerful strategy which can empower us to control instability and to achieve intimate gas-solid contact in gas-fluidized bed reactors. This method holds the key to uniform fluidization of fine cohesive powders on the micro- and nanoscales.

Experiment





Phase diagram corresponding to two typical frequencies in conventional Fluidized Bed. Two regimes with regular and less-regular (right) patterned flows are produced in a modulated gas-driven granular layer, coupled with bed expansions.



Macro-scale wave excitation and an expansive layer

31 Hz

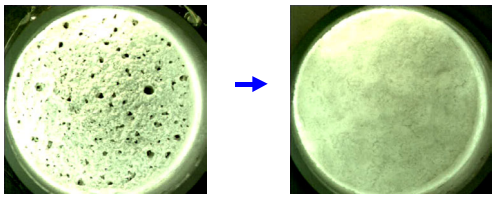
Bronze particles, 150μm – ***controlled regular*** patterns

20 Hz 22 Hz 23 Hz

The spectrum analysis of the pressure drop reveals two typical frequencies in conventional fluidized beds related to: 1) the oscillation of the particle layer and to 2) bubbling, - an expression of a non-equilibrium dissipative system.

Superimposing a modulation flow to the above system results in the appearance of fascinating patterns (see figure on the right) over a narrow frequency interval outlined by the colored-blocks above.

Cohesive particles/flour, 20 *μm* – ***suppression*** of channels



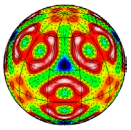
no modulation
channels

8 Hz modulation
uniform fluidization

Results

We developed a new method which dramatically improves gas-solid contact in fluidized bed reactors. We demonstrated that controlled modulation flow leads to an effective suppression of flow instability and dramatic improvement of fluidization quality by evoking the resonance with the intrinsic bed fluctuations. Future work will focus on the fluidization of ***nano-powders*** in a ***deep*** bed with the potential application for hydrogen and nanotube production.

Jie Li, I. S. Aranson, W. K. Kwok and L.S. Tsimring, Phys. Review Lett., vol. 90, 134301, 2003. Contact: Jieli@anl.gov



BES - DOE

This work was supported by the U. S. Department of Energy, Basic Energy Sciences, under contract W-31-109-ENG-38.

MSD - ANL

ARGONNE NATIONAL LABORATORY · UNIVERSITY OF CHICAGO